State of California
The Resources Agency
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Los Rios Farms Conjunctive Use Project
DRAFT

April 1997

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Introduction

This report supplements the SWP Conjunctive Use – Eastern Yolo County Prefeasibility Study. Only new assumptions and criteria, changes in previous assumptions, and changes in delivery system layout and design are in this report. It quantifies the conjunctive use potential of a specific area within the previous study area boundary. This report documents the development of a preliminary facilities design and cost estimate for a conjunctive use project involving Los Rios Farms and adjacent agricultural land. The specific area is bounded by the Toe Drain on the east, by the Yolo/Solano county line on the west, and the Los Rios Farms property boundary to the north and south. Figure 1 shows the project area boundary.

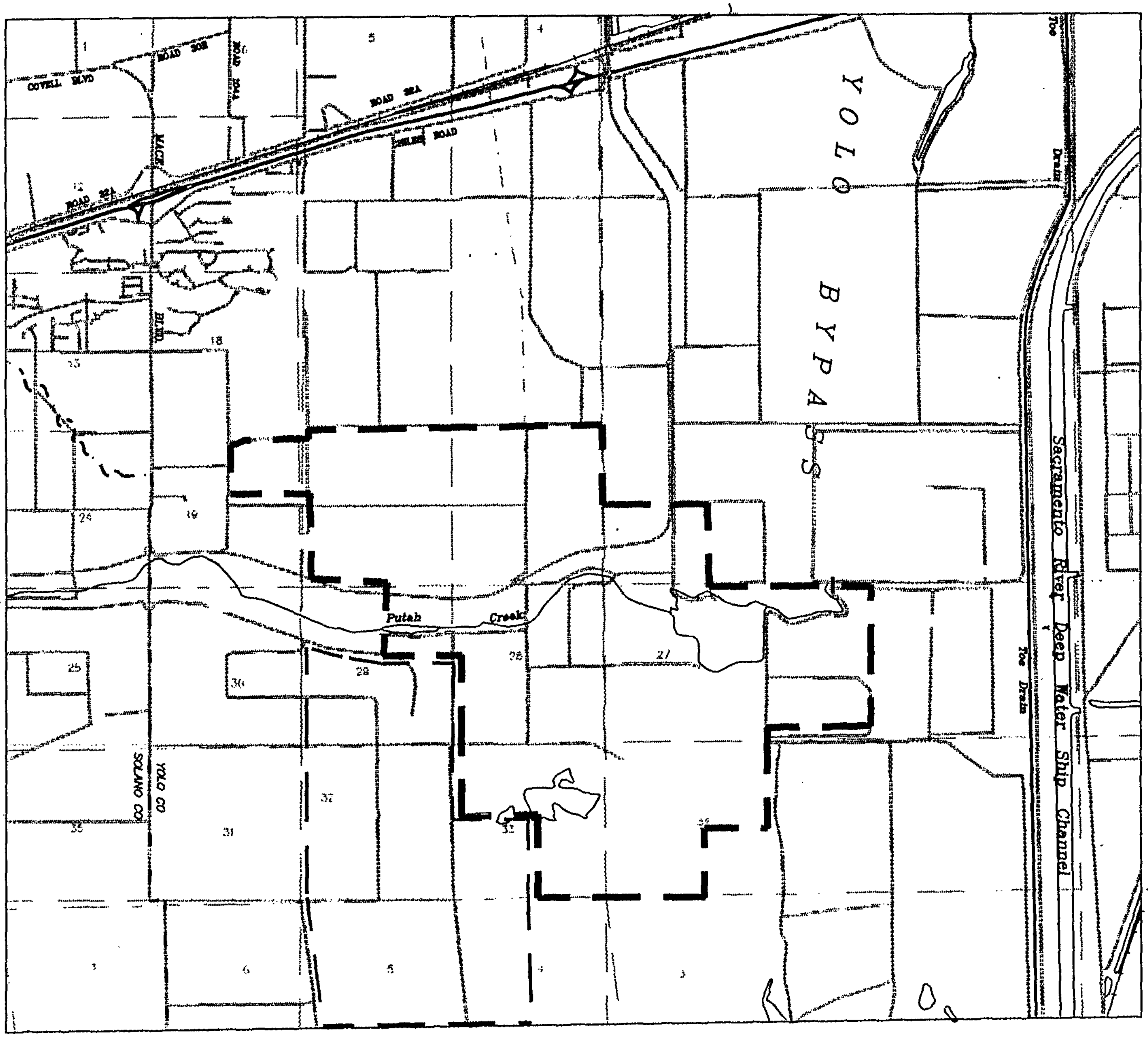
Project Description

This proposed conjunctive use project consists of 2,080 acres of irrigated agricultural land and the adjacent Los Rios Farms property. The 2,080 acres were selected as potential in–lieu recharge area because of its dependence on groundwater and its proximity to existing surface water supply sources, which are Putah Creek and the Toe Drain.

The project contains two components: project recharge and project recovery. Project recharge would occur during wet and above normal water years. This component would provide an annual surface water delivery of 7,150 acre–feet to the 2,080 acres of groundwater–dependent agricultural land. The surface deliveries will offset demands on groundwater which will allow the aquifers to replenish naturally. The proposed facilities required to convey and distribute the surface water deliveries within the in–lieu recharge area are detailed in the Project Facilities section of this report.

The second component involves recovering the recharged water which would occur during dry and critical years. This would be accomplished by groundwater substitution. Los Rios Farms would reduce diversions from the Toe Drain, thereby making the water available to the State Water Project, and then would substitute a like amount of groundwater to obtain a full supply. Based on the project assumptions an extraction occurrence would consist of 10,830 af. The groundwater–dependent area would simply return to groundwater pumping to meet 100 percent of their demands.

Two project alternatives were developed for this report. The first alternative involves the two primary components and assumes a 40–year project life. The second alternative involves the same components, assumes a 10–year project life, and evaluates the feasibility of implementing a demonstration conjunctive use project. The second alternative would provide an opportunity for the physical and institutional parameters to be operated on a trial basis with only a 10–year commitment of resources by all involved parties.



CONJUNCTIVE USE STUDY
South of Interstate 80

Project Area

Figure 1

Proposed In Lieu Recharge Area (2080 acres)

Los Rios Farms Property Boundary

Project Facilities

Surface Water Delivery System

The proposed surface water delivery system was designed to operate using existing surface water conveyance facilities wherever possible. The existing and proposed peak demands were considered when using existing facilities for conveyance and the facilities were modified accordingly. The development of the design flow rates, conveyance facilities design, and pumplift designs were developed using the criteria established in the SWP Conjunctive Use – Eastern Yolo County Prefeasibility Investigation, and the modifications outlined in the following sections.

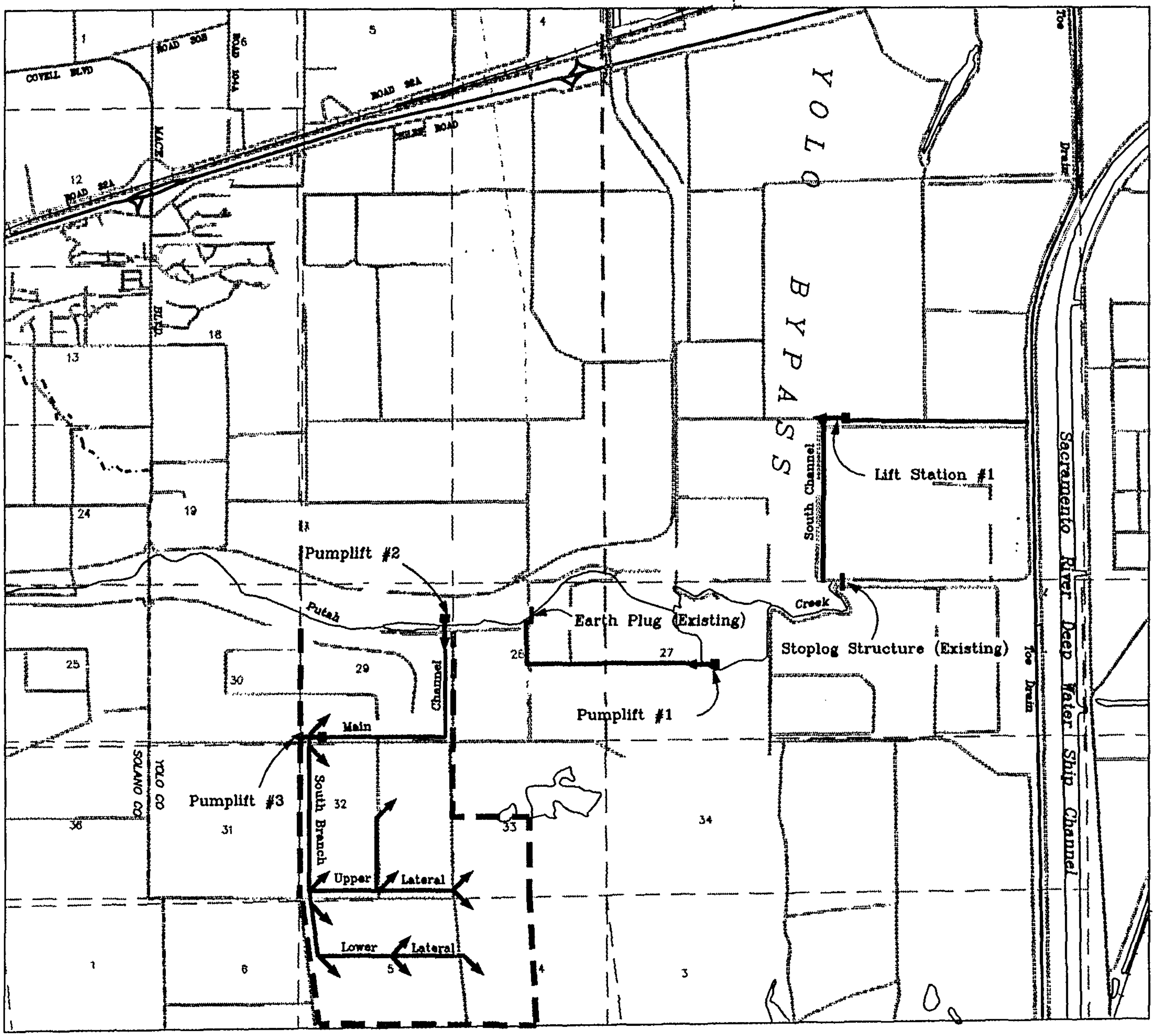
The proposed delivery system involves the modification and construction of unlined open channels, buried pipelines, pumplifts, pump–turnouts, and various road crossings and control structures. It is capable of delivering a reliable supply at the rate of 50 cfs from the Toe Drain to the 2,080 acre project area. The layout of the proposed facilities is shown on Figure 2.

Design Flow Rates

The crop mix for the 2,080 acre project area used to determine the design discharge rates is as follows:

Crop	% Gross Area
Fallow	15
Corn	20
Tomatoes	30
Alfalfa	30
Barley	5

A series of assumptions regarding the acreage served, operational parameters, flexibility factors, and conveyance losses were developed to determine the design flow rates for each delivery system component. The irrigation efficiency is 60 percent. The applied water demand was calculated based on the average evapotranspiration rate for the given crop mix and the irrigation efficiency.



CONJUNCTIVE USE STUDY
South of Interstate 80

Potential In Lieu
Ground Water Recharge
Area with Facilities

Figure 2

- Proposed In Lieu Recharge Area (2080 acres)
- Pump Lift
- Open Channel (Proposed)
- Field Headgate
- Open Channel (Existing)

Flexibility factors were applied based on the quantity of area served. The smallest increment of area served by this system (field headgate) is 160 acres. This increment of area will require the most flexibility and therefore, the demand was increased by a factor of 2. This allows irrigation to occur 12 hours per day on 100 percent of the cropped area during the month of maximum demand. The headgate flexibility factor was weighted by the ratio of maximum evapotranspiration rate/average evapotranspiration rate. The resulting weighted flexibility factor is 2.7. This allows the operational parameters above to be met for an area of 160 acres planted with the crop that has the highest evapotranspiration rate (corn). The resulting design flow rate at the field headgates, assuming a conveyance loss of 10 percent, is 22 gpm/acre.

The total recharge area (2,080 acres) requires less flexibility. Therefore, the applied water demand (again based on the average evapotranspiration rate for the given crop mix and the irrigation efficiency) for the recharge area is increased by a flexibility factor of only 1.25 which accommodates a 25 percent outage. The flexibility factor for the project area was not weighted by the maximum evapotranspiration rate as was the field headgate. It is unlikely that the entire project area will be planted with the maximum demand crop simultaneously. This results in a project design flow rate of 11 gpm/acre for a total of 50 cfs. The remaining delivery facilities were sized using this method, assuming the weighted flexibility factors vary linearly with the area served. The resulting weighted flexibility factors vary from 2.7 (applied to field area) to 1.25 (applied to project area).

Conveyance Facilities

The project irrigation deliveries are conveyed by a primary system of existing and proposed channels with a diversion from the Toe Drain. The existing open channel (from the Toe Drain to Lift Station #1) is adequate for conveying 50 cfs plus the existing maximum capacity of Lift Station #1 which is 119 cfs. Lift Station #1 is located 1.25 miles west of the Toe Drain. After being lifted 12 feet, the water is conveyed one mile south in an existing channel (South Channel) and discharged into the Putah Creek channel. The South Channel is currently operated at about two–thirds of the capacity of Liftstation #1 or 80 cfs. Based on preliminary surveying data, the South Channel has the capacity of about 170 cfs which would accommodate an additional project flow rate of 50 cfs. Also, four 30–inch culverts downstream of Liftstation #1 discharge into the South Channel and have a cumulative capacity of 150 cfs (assuming a discharge coefficient of .60 and a hydraulic head of 2.5 feet). Therefore, installation of an additional culvert is not required to facilitate project recharge.

The South Channel would tie–in to the creek upstream of an existing flashboard/bridge structure. This structure raises the water surface elevation in the creek to provide sufficient submergence at Pumplift #1, which would be located one mile southwest of the Putah

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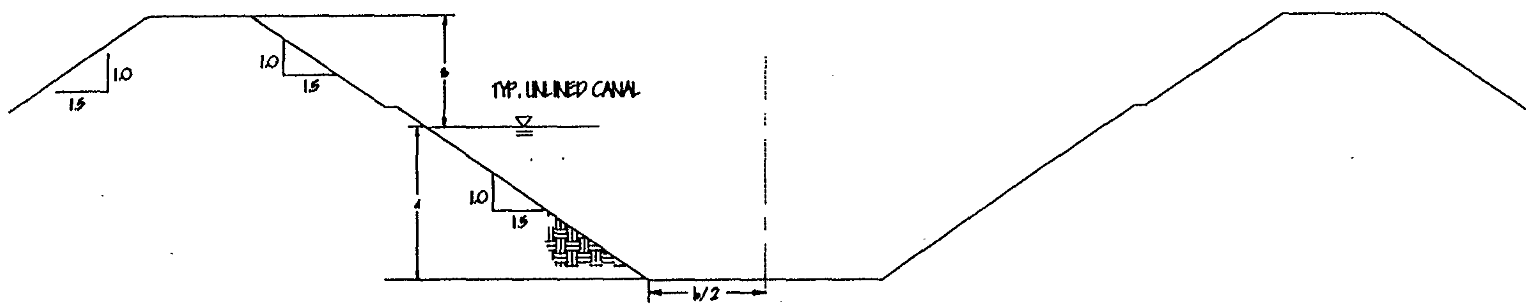
Creek/South Channel tie–in. Pumplift #1 will consist of a new structure and mechanical components adjacent to the existing pump–turnout structure.

Water is then conveyed through existing channels one mile west and one–quarter of a mile north and discharged into the Putah Creek channel upstream of an existing earth plug in the creek. Minor improvements are required to increase the capacity of this channel. The earth plug raises the water surface elevation in the creek to provide adequate submergence at the proposed Pumplift #2 (one half–mile west of the earth plug). Although a pump–turnout structure exists at this location, this project requires a new, independent structure to be constructed. This proposed turnout lifts water out of the creek channel and discharges into the proposed Main Channel which is the start of the secondary delivery system. The estimated storage within the portion of Putah Creek channel used in this flow regime is 150 af. This storage will provide additional operational flexibility.

The secondary delivery system consists of 3.7 miles of earthen canal with a 10–foot bottom width and 2.5 miles of earthen canal with a 3–foot bottom width. The maximum design velocity for earthen canals is 1 fps except for the Main Channel which is designed to be operated at 2 fps during maximum demand. Other open channel design criteria include: 1.5:1 sideslopes on all channels, a Mannings coefficient of .027, and all canal inverts are either 10 feet ($Q >$ 25cfs) or 3 feet ($Q <$ 25cfs) to accommodate common sized excavation equipment. A summary of open channel design parameters is shown in Table 1.

Further assumptions were made regarding the earthwork required to construct the open channels. Due to shallow groundwater, hydraulic excavation will be required for depths of 5 feet or greater (applies to Main Channel only). All other 10–foot inverts will be constructed with a scraper and dozer, and spoil material will be spread on adjacent fields. Road and personnel crossings are provided only where the proposed conveyance system crosses an existing corridor.



CHANNEL SECTION	STATION	b (ft)	d (ft)	Q (cfs)	MINIMUM FREEBOARD (ft)
Primary Channel	0+00 - 90+80	10	3.5	50	2.5
South Branch (Reach 1)	0+00 - 52+80	10	3.0	50	1.5
South Branch (Reach 2)	0+00 - 26+40	10	2.5	33	1.5
Upper Lateral (Reach 1)	0+00 - 26+40	10	2.5	27	1.5
Upper Lateral (Reach 2)	0+00 - 26+40	3	2.5	15	1.5
North Leg	0+00 - 26+40	3	2.5	8	1.5
Lower Lateral (Reach 1)	0+00 - 26+40	3	2.5	15	1.5
Lower Lateral (Reach2)	0+00 - 52+80	3	2.5	8	1.5

Table 1

Open Channel Cross-Sections

Pumping Plants

Several factors were considered in siting the pumplifts and pump turnouts. The sites were chosen to minimize conflict with existing utilities and for easy access from traffic corridors. Whenever possible existing pumplifts were modified and used instead of constructing new sumps, platforms, and other structural components. No excess capacities are available (for project use) in the mechanical components of the existing pumplifts. Lift sites were chosen to minimize pumplifts while minimizing the static lift at each station; the maximum lift at any one pump was limited to about 12 feet. Although an attempt was made to design the pumplifts with the same pump/driver combination, the large differences in flow rates and static lifts required the using a variety of configurations. Each pump–turnout is designed with low lift axial flow pumps with electric motors. Pumplift #3 is designed with a diesel engine reducing energy and stand–by costs and providing more operational flexibility. Pumplift #3 also avoids the additional capital cost of a power line to the site. Canal inverts were placed at or below stripped ground level downstream from the pumplifts.

Modifications to the existing Lift Station #1 includes adding a new pump support bay to the existing structure. The required structural components include: four H–piles, horizontal steel supports, and platform grating. A profile of Lift Station #1 and the proposed modifications are shown in Figure 3. The mechanical components consist of a 50 cfs axial flow pump with a 36–inch diameter intake. A 125–horsepower electric motor is required for the assumed parameters. The unit costs for the pump and motor were provided by a local manufacturers. A 42–inch diameter welded steel discharge line with an air release valve will be constructed adjacent to the existing discharge lines. The existing pump sump, access platform, trashracks, and sheet piles have adequate hydraulic parameters and structural integrity for the additional 50 cfs capacity. A summary of the proposed pumplift design features is shown in Table 2.

A new isolated structure will need to be constructed for the first Putah Creek pump–turnout (Pumplift #1). The existing timber structure is not capable of resisting additional loading because of the installation of a 50 cfs pump and motor. Therefore, a new

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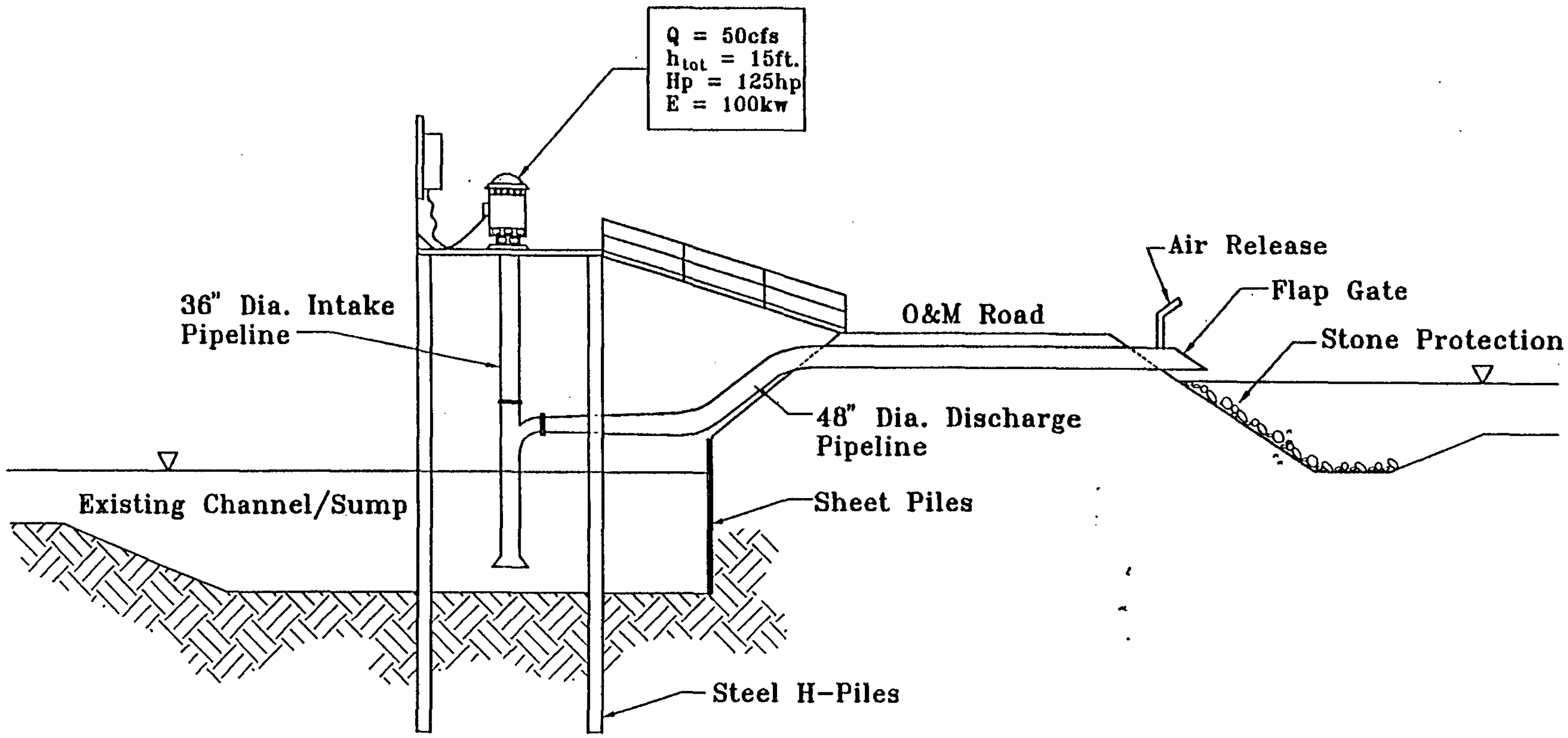

Figure 3

Los Rios Farms
Conjunctive Use Study

Lift Station #1
Modification Profile

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Table 2
Summary of Pumplift Design Features

Pumplift	Unit	Driver Type	Motor Size (hp)	Static Lift (ft)	Capacity (cfs)
LS1	1	Electric	125	12	50
#1	1	Electric	100	11	35
#1	2	Electric	45	11	15
#2	1	Electric	100	11	35
#2	2	Electric	45	11	15
#3	1	Diesel	45	8	15
#3	2	Diesel	150	8	50

structure is proposed which consists of steel H–piles, horizontal supports, floor grating, trashracks and access ramp. Sheet piles are not required to develop a sump because the intake line will be submerged directly into the creek channel. In order to provide more operational flexibility two pump/motor units will be installed. The mechanical components will consist of a 100 horsepower electric motor, 35 cfs pump, and a 36–inch diameter welded steel discharge pipeline with a flap gate and air release valve. The second unit consists of a 45 horsepower electric motor, 15 cfs pump, and a 24–inch diameter welded steel discharge pipeline with a flap gate and air release valve. It is assumed that adequate flow variation is available with the two units and the reservoir–like dampening ability of Putah Creek.

The second proposed Putah Creek pump turnout (Pumplift #2) will be constructed identically to Pumplift #1. Since the design capacities and static lifts are the same, the structural and mechanical components will be the same.

Pumplift #3 is located at station 90+80 of the secondary delivery system, at the west end of the Main Channel. This configuration has two pumping units, each dedicated to specific service areas. The general plan and profile are shown in Figure 4 and Figure 5, respectively. The pump sump will consist of a 10 foot long x 16 foot wide x 16 foot deep concrete sump. Unit #1 supplies the area north of the main channel and south of the levee and has a design capacity of 15 cfs with a static lift of 8 feet. The mechanical components of unit 1 include a 45 horsepower diesel motor with a right angle gear drive and a 15 cfs capacity pump with a 24–inch diameter one–forth inch welded steel discharge pipeline. Unit #2 supplies the area south of Road 35 and has a design capacity of 50 cfs with a static lift of 11 feet. The mechanical components include a 150 horsepower diesel motor with a 50 cfs pump with a 42–inch diameter welded steel discharge pipeline.

Project Roads

The existing roadway network within the project area will provide adequate access to the proposed facilities. Therefore, no roads were planned for this project.

Groundwater Extraction System

The same assumptions were used to estimate Los Rios Farms' average annual water demand that were used to estimate the design flow rates for the proposed surface water delivery system for the 2,080–acre project area. This yielded a demand of 16,000 af/per year. It is assumed that the twelve existing wells on Los Rios Farms have an average discharge capacity of 5 cfs which is adequate to meet the estimated peak monthly demand of 3,500 af which occurs in July. Furthermore, correspondence with the owner of Los Rios Farms confirmed the capability to meet 100 percent of the irrigation demands with the existing wells, pumps, motors, and conveyance facilities. Therefore, no capital costs were included for groundwater extraction facilities in this cost analysis.

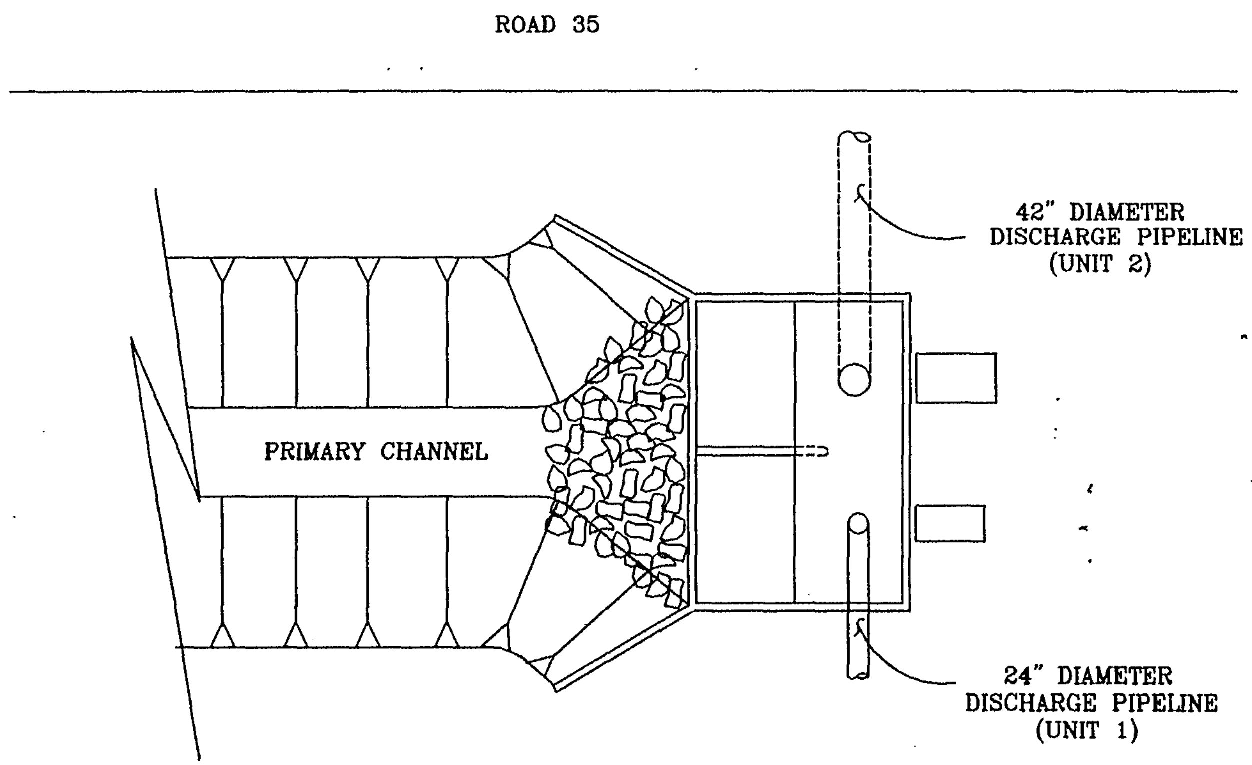

FIGURE 4

LOS RIOS FARMS
CONJUNCTIVE USE STUDY

PUMPLIFT #3
PLAN VIEW

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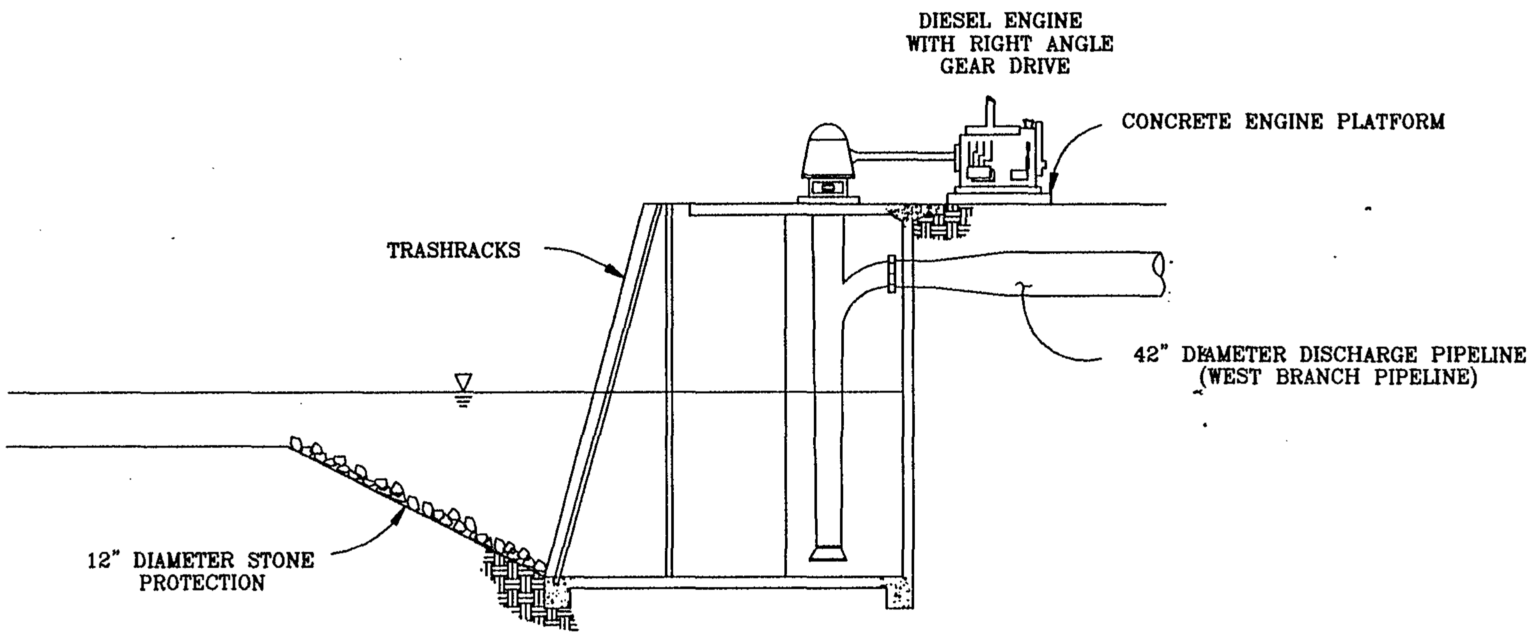

FIGURE 5

LOS RIOS FARMS
CONJUNCTIVE USE STUDY

PUMPLIFT #3
PROFILE

Estimated Costs and Economic Analysis

Capital Costs

Assumptions and Criteria

The capital cost estimate was developed using the criteria established in the SWP Conjunctive Use – Eastern Yolo County Prefeasibility Investigation with the following additions and modifications:

Diesel engine and electric motor costs were obtained from manufacturers. Recharge pump costs were obtained from pump manufactures. Labor, materials, and other related construction costs were obtained from Means Heavy Construction Cost Data, 1994 ed. Compensation for agricultural land that is affected by the proposed delivery system is considered in this analysis. The capital cost estimate does not include costs incurred during or as a result of project negotiations. Water quality and subsidence monitoring costs were not considered in this analysis.

Summary of Capital Costs

The new facilities required to convey in–lieu surface water deliveries to the 2,080–acre recharge area are estimated to cost $1.54 million. The specific items and their respective costs are shown in Table 3.

Surface Water Delivery System
Summary of Construction Costs

Item	Quantity	Unit	Unit Cost	Item Cost
Open Channels				
Improvements to Existing Channels	5.820	LF	$5	$29.100
Main Channel	9.080	LF	$10	$90.800
South Branch (Reach 1)	5.280	LF	$7	$36.960
South Branch (Reach 2)	2.640	LF	$7	$18.480
Upper Lateral (Reach 1)	2.640	LF	$5	$13.200
Upper Lateral (Reach 2)	2.640	LF	$4	$10.560
North Leg	2.640	LF	$5	$13.200
Lower Lateral (Reach 1)	2.640	LF	$5	$13.200
Lower Lateral (Reach 2)	2.640	LF	$5	$13.200
Open Channels Subtotal				**$238,700**
Road Crossings/Control Structures				
2 - 24" CMP Road Crossing	80	LF	$70	$5.600
3 - 30" CMP Road Crossing	120	LF	$90	$10.800
2 - 48" CMP Road Crossing	80	LF	$110	$8.800
Turnout	12	EA	$3.500	$42.000
Check/Drop Structure	3	EA	$2.250	$6.750
Road Crossings/Control Structures Subtotal				**$73,950**
Pumplifts				
Improvements to Lift Station #1	1	EA	$120.000	$120.000
Pumplift #1	1	EA	$167.400	$167.400
Pumplift #2	1	EA	$167.400	$167.400
Pumplift #3	1	EA	$169.500	$169.500
Pumplift Subtotal				**$624,300**

Facilities Subtotal	**$936.950**
Contingencies (25%)	**$234,238**
Subtotal	**$1,171,188**
Engineering and Administration (25%)	**$292,797**
Compensation for Lost Crop Land (38 acres @ $2,000/ac)	**$76,000**
Facilities Total	**$1,540,000**

TABLE 3

Operation and Maintenance Costs

Assumptions and Criteria. The estimated operation and maintenance costs were developed using the criteria established in the SWP Conjunctive Use – Eastern Yolo County Prefeasibility Investigation and the modifications outlined in the following section. Average annual costs were developed by obtaining an annual cost for each occurrence and then applying 50 percent for a recharge occurrence, 30 percent for an extraction occurrence, and 20 percent for an idle occurrence to each year of the project life. Management costs were not considered in this analysis.

Surface Water Delivery System. The operation and maintenance costs with project recharge are as follows: The cost of diesel fuel and electric energy required to pump recharge water includes dynamic losses from the suction flange to the discharge flange; diesel engine operation and replacement costs are based on a manufacturers recommendations (Sierra Detroit Diesel); recharge pump maintenance costs are 1/10 of the capital cost and occur every other year; a diesel fuel cost of $1/gal was used for this analysis; storage cost for recharge pump motors when not in use was not considered in this analysis; and recharge power costs are based on pump–driver efficiencies for electric and diesel drivers of 70 percent and 60 percent, respectively. A melded power rate of $.09 per kilowatt–hour was assumed. The unit power cost at Liftstation #1, Pumplift #1, and Pumplift #2 is about $2 per af, respectively. The unit fuel cost at Pumplift #3 is about $1.90 per af.

Groundwater Extraction System. The following assumptions and design criteria were used to develop the groundwater extraction operation and maintenance costs:

- ❑ Repair/Replacement costs for extraction pumps and motors were not considered in this analysis.
- ❑ Dynamic losses from the pump column to the discharge outlet were considered in estimating the extraction energy costs.
- ❑ The efficiency of the extraction pump– motor unit is 70 percent.
- ❑ The average discharge flow capacity is 5 cfs.
- ❑ The average static lift is 100 ft with an assumed dynamic loss of 10 feet.
- ❑ A melded power rate of $.09/kwh was used based on the Kern Fan Element Re–evaluation Study. This rate reflects stand–by charges and appropriate operational rate schedules. This results in a unit energy cost of $17 per af (based on a unit energy requirement of 188 kwh per af).

Summary of Operation and Maintenance Costs. The average annual operation and maintenance costs required to convey in–lieu surface water deliveries to the 2,080–acre recharge area were estimated at $87,700.

Economic Analysis

Assumptions and Criteria

An average annual recharge and extraction of 3,250 af is used based on the crop demand developed in the *Design Flow Rates* section of this study. The economic analysis is also based on the following criteria:

- A 40–year analysis period was used for Alternative I.
- A 10–year analysis period was used for Alternative II.
- Construction costs occur in year 0.
- A discount rate of 6 percent was used.

Summary of Economic Analysis

Results of the economic analysis yielded a cost of constructing, maintaining, and operating the project facilities, which is presented as a cost per acre–foot of $50 for the 40–year alternative and $80 for the 10–year alternative. The results of the economic analysis are presented in Table 4 and Table 5.

Economic Analysis
(40 Year Project Life)

TOTAL CAPITAL COST (Equivalent Annual Costs)	$102,351
ANNUAL O&M COST	$87,700
TOTAL EQUIVALENT ANNUAL COST	$190,051
AVERAGE ANNUAL YIELD (acre-feet)	3,575
UNIT COST (Dollars per ac-ft)	**$50**

TABLE 4

Economic Analysis
(10 Year Porject Life)

TOTAL CAPITAL COST (Equivalent Annual Costs)	$209,237
ANNUAL O&M COST	$87,700
TOTAL EQUIVALENT ANNUAL COST	$296,937
AVERAGE ANNUAL YIELD (acre-feet)	3,575
UNIT COST (Dollars per ac-ft)	**$80**

TABLE 5

Conclusions

From engineering, topographical, geographical, and economic standpoints this proposed area lends itself well to the construction and operation of a conjunctive use project. The relative locations of Los Rios Farms, the adjacent groundwater–dependent area, and the surface water supply results in a prime configuration for such a project. Furthermore, the existence of a surface water delivery system (portions of which have excess capacity available) from the Toe Drain to the in–lieu recharge area reduces the capital expenditure necessary to deliver water to the recharge area. The fact that Los Rios Farms currently has the capability to meet 100 percent of its demands with groundwater (including wells, pumps, motors, and conveyance facilities) substantially reduces project capital costs. Also, the minor elevation differential between the Toe Drain water surface and the proposed in–lieu recharge area allows surface water deliveries with very few pumplifts and low energy costs.

The capital cost required for full project build–out is $1.54 million; of which $1.20 million is necessary for construction of the distribution system within the recharge area. The capital cost is the same for both alternatives since the same facilities are required regardless of the project life. The estimated annual operation and maintenance cost is $87,700. Therefore, the total annual project costs for the 40–year and 10–year alternatives are $190,000 and $297,000, respectively. The estimated average annual project yield for both alternatives is 3,250 af. The resulting unit costs are $50 per acre–foot and $80 per acre–foot, respectively. Based on a recharge capability of 6,500 af per occurrence (during wet and above normal water years), the project yield during an extraction occurrence (dry and critical years) is estimated to be 10,830 af.